Astronomy

ES-2 The student will demonstrate an understanding of the structure and properties of the universe.

Key Concepts for ES-2:
Solar System: formation, properties, planets
Moon: properties & features, uniqueness
Big Bang Theory: expansion of the universe; red shift
Formation of elements: nuclear fusion; supernova
Hertzsprung-Russell diagram:
Telescopes: visual – reflecting & refracting; x-ray; radio
Life Cycle of Stars: birth, main sequence, death – supernova, black hole
Galaxies: formation & shapes, effects of gravity & motion
Technology & Computer Modeling:

ES-2.1 Summarize the properties of the solar system that support the theory of its formation along with the planets.
Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/future knowledge: Students in 4th grade (4-3.1) recalled Earth as one of many planets in the solar system. The characteristics and movements of objects in the solar system were introduced in 8th grade (8-4.1). Students have not been introduced to the theory of the formation of the solar system.

It is essential for students to know properties that are evident within the solar system that support the *nebular theory* of its formation.

- Stars and planets form from clouds of gas and dust, called interstellar clouds that exist between the stars. This interstellar cloud material can be observed in regions along the Milky Way.
- The collapsing of interstellar cloud material along with its rotating motion is the beginning of the flattened rotating disk that became the solar system.

The nebular theory continues to explain the formation of the Sun and then planetesimals, many of which formed the planets.

- The terrestrial/rocky planets near the Sun formed from denser elements and compounds such as iron and silicon that were not driven away by energy radiating from the forming Sun.
- The outer planets formed farther from the Sun where energy levels were lower.
- Other remnants from solar system formation are asteroids and comets.

It is not essential for students to know physics, such as angular momentum, behind the formation process or the specific formation of the individual bodies within the solar system.

Assessment Guidelines:
The objective of this indicator is to *summarize* major points about the formation of the solar system; therefore, the primary focus of assessment should be to generalize major points about the nebular theory.
In addition to *summarize*, appropriate assessments may require students to:

- *compare* the formation of the inner and the outer planets;
- *sequence* the events in the formation of the solar system; or
- *identify* objects that formed in the solar system.

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ES-2.2 Identify properties and features of the Moon that make it unique among other moons in the solar system.
Taxonomy level: 1.1-B Remember Conceptual Knowledge

Previous/future knowledge: Students in 4th grade compared the motion and surface features of the Moon to the Sun and the Earth. They also developed an understanding of the Moon's position in relationship to Earth and the Sun. In 8th grade students summarized characteristics of the Moon, including phases, eclipses, and tides, along with other objects in the solar system. This is the first time that properties and features of the Moon, including its surface, have been studied in relation to other moons.

It is essential for students to know that the Moon as Earth's natural satellite is unique among the moons in the solar system.

Unique Properties:

Size	The Moon is one of the largest in the solar system, especially compared to the size of the planet it orbits. Also, the Moon is the only large moon among the inner planets. (Mercury and Venus have no moons, and the moons of Mars are just two chucks of rock).
Orbit distance	The Moon's orbit is relatively farther from Earth than most moons are from the planets they orbit.
Composition	The Moon is a solid, rocky body, in contrast to the icy composition of the moons of the outer planets.

Features:

Craters	All the craters on the Moon are impact craters.
Rays	Long trails of material (ejecta) blasted out from impacts on the Moon radiate out from craters.
Maria	These are dark, smooth plains of lower elevation on the Moon; they may contain craters and small meandering, valley-like structures.
Highlands	Cover most of the lunar surface, are mountainous, and are heavily covered with craters.
Atmosphere	The Moon has no atmosphere.

Other features of the moon due to its movement and relation to Earth are its phases and its gravitational effect causing tidal pull on Earth.

- Because of its size and the fact that the same side of the Moon always faces Earth, the illuminated side of the Moon that can be seen from Earth goes through sequential changes called phases. Students can revisit this concept as they study the unique properties and features of Earth's Moon.
- Because of its size and its close proximity to Earth, the Moon's pull of gravity creates bulges of ocean water on both the near and far sides of Earth. As Earth rotates, these bulges remain aligned with the Moon so that the ocean level rises and falls about every 12 hours. The Sun's gravitational pull also has an effect on the formation of tides, but it is about half that of the Moon.

It is not essential for students to know all the moons of the solar system or exactly how many moons each planet has.

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Assessment Guidelines:

The objective of this indicator is to *identify* properties and features of the Moon; therefore, the primary focus of assessment should be to have students retrieve from memory information related to the Moon's properties and features.

In addition to *identify* appropriate assessments may require students to:

- *identify* a particular feature from its description; or
- *recall* how the Moon is unique from other moons based on a particular property.

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ES-2.3 Summarize the evidence that supports the big bang theory and the expansion of the universe (including the red shift of light from distant galaxies and the cosmic background radiation).
Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/future knowledge: The big bang theory and the expansion of the universe is a new concept for this course; it has not been presented in any previous grades.

It is essential for students to know that the *big bang theory* states that the universe began as a concentrated point of matter and energy that was propelled outward and has been expanding ever since. As gravity began to have an effect, galaxies formed. The galaxies continued to move outward. There is another theory, the steady-state theory, but evidence weighs in favor of the big bang. Evidence that students need to investigate includes the red shifts of galaxies and cosmic background radiation.

It is not essential for students to compare the big bang theory to other theories. An understanding of critical density and the ultimate fate of the universe based on this theory are not necessary at this time.

Assessment Guidelines:
The objective of this indicator is to *summarize* evidence that supports the big bang theory and that the universe is expanding; therefore, the primary focus of assessment should be to generalize major points concerning this evidence.
In addition to *summarize* appropriate assessments may require students to:

- *infer* from scientific evidence the idea that the universe is expanding; or
- *explain* how each piece of evidence is important to the overall theory.

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ES-2.4 Explain the formation of elements that results from nuclear fusion occurring within stars or supernova explosions.
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/future knowledge: The formation of elements as a result of nuclear fusion within stars or exploding supernovas is a new concept for this course; it has not been presented in any previous grades.

It is essential for students to have a basic understanding of the process of nuclear fusion. The temperature inside a star governs that rate of nuclear fusion.

- Stars in the main sequence all produce energy by fusing hydrogen into helium as the Sun does.
- Stars outside the main sequence may fuse different elements in their cores or may not undergo fusion at all.
- Once a star's core has been converted from hydrogen to helium, if the temperature is high enough, the helium may fuse to form carbon. This is the second nuclear fusion reaction phase of a star.
- At even higher temperatures other elements such as oxygen, neon, magnesium and silicon may form. Stars can produce few elements heavier than iron.
- When the outer portion of a star is blown off in a massive explosion, known as a supernova, elements heavier than iron are created and enrich the universe.
- The star's element composition is determined by how many fusion reaction phases it has gone through.

It is not essential for students to diagram the fusion process or write nuclear fusion equations. The comparison of nuclear fission and fusion is not part of this indicator.

Assessment Guidelines:
The objective of this indicator is to *explain* the formation of elements within stars as a result of nuclear fusion; therefore, the primary focus of assessment should be to construct cause and effect models about the formation of elements based on the fusion reaction element involved.
In addition to *explain* appropriate assessments may require students to:

- *summarize* the process of nuclear fusion;
- *infer* how heavier elements could result from a supernova explosion;
- *recall* elements formed from nuclear fusion in stars; or
- *identify* the elements formed in the first two fusion reaction phases.

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ES-2.5 Classify stars by using the Hertzsprung-Russell diagram.
Taxonomy level: 2.3-B Understand Conceptual Knowledge

Previous/future knowledge: The Hertzsprung-Russell diagram and its use as a classification tool for stars is a new concept for this course; it has not been presented in any previous grades.

It is essential for students to know that the properties of mass, magnitude/brightness, temperature and diameter of stars are closely related. This relationship has been shown on a chart known as the Hertzsprung-Russell diagram (H-R diagram).

Absolute magnitude	This property of brightness is plotted on the vertical axis of the chart.
Spectral type	This property is found on the lower horizontal axis. Stars are given a letter and number based on the pattern of spectral lines produced by the star and temperature. O stars being the hottest and M stars being the coolest.
Surface temperature	Measured in Kelvin is located along the top horizontal axis. Highest temperatures are on the left to coolest temperatures on the right.

Students will need to use these properties on the axes of the chart to classify stars.

Main sequence	90% of stars, including the Sun, are found along a diagonal that runs from the upper left where hot, bright stars are found to the lower right where cool, dim stars are found. All these stars have similar internal structures and functions.
Giants	These stars are found in the upper right of the chart. They are cool stars with large surface areas that are bright, so they are called red giants.
Dwarfs	Dim, hot stars are plotted in the lower left corner. They are small or they would be brighter. These are called white dwarfs.

It is not essential for students to classify individually named stars, but understanding the meaning of the placement of a star on the chart is necessary.

Assessment Guidelines:
The objective of this indicator is to *classify* stars through the use of the Hertzsprung-Russell diagram; therefore, the primary focus of assessment should be to place stars into a classification according to the properties shown on the diagram.
In addition to classify appropriate assessments may require students to:

- *interpret* the chart as to the meaning of the factors on the horizontal and vertical axes;
- *exemplify* stars found in various locations on the chart; or
- *identify* the classification of the Sun based on the H-R diagram.

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ES-2.6 Compare the information obtained through the use of x-ray, radio, and visual (reflecting and refracting) telescopes.
Taxonomy level: 2.6-B Understand Conceptual Knowledge

Previous/future knowledge: Students in 4th grade were introduced to the telescope as a tool of astronomers. In 8th grade students compared the purpose of tools and technology that scientists use, including the telescope, but not the structure of telescopes. In Earth Science students will now compare specific telescopes in order to determine the information that can be gathered from each type.

It is essential for students to know that x-ray, radio, and visual telescopes are each constructed in such as way as to allow information to be gathered regarding objects and events in the universe. Objects in space emit radiation in all frequencies of the electromagnetic spectrum. Some of the wavelengths the human eye cannot detect so a variety of telescopes have been developed. The goal of all telescopes is to bring as much radiation as possible to a focus.

X-ray Telescopes

- Since x-rays cannot be easily reflected by any surface, a special design for detecting x-rays had to be developed.
- An arrangement of cylindrical mirrors allows X-rays to be guided to a precise focus to form an image.

Visual Telescopes

Reflecting

- Uses a concave mirror instead of an objective lens to focus a large amount of light onto a small area; the larger the mirror, the more light the telescope can collect;
- A flat mirror reflects the light to the eyepiece lens.
- The majority of visual telescopes used today are reflecting.

Refracting

- Uses convex lenses to bring visible light to a focus;
- The largest lens is called the objective lens; the second lens is the eyepiece lens;
- When light passes through the objective lens, the lens focuses the light at a certain distance away from the lens; the larger the objective lens, the more light it can collect.

Radio Telescopes

- Most radio telescopes have curved, reflecting surfaces that are used to detect radio waves from object in space;
- The surface of the telescope concentrates faint radio waves onto small antennas.

It is not essential for students to use ray diagrams to trace the path of incoming radiation into the various telescopes. It is not necessary for a complete study of the Hubble Space telescope to be part of this indicator, but it may make an interesting additional study.

Assessment Guidelines:
The objective of this indicator is to *compare* information gathered from types of telescopes; therefore, the primary focus of assessment should be to detect ways that these instruments are alike or different in regards to the collection of information from space.
In addition to *compare* appropriate assessments may require students to:

- *interpret* diagrams that show how a telescope collects information;
- *compare* the visual reflecting and refracting telescopes; or
- *identify* a telescope based on a description of the information it is able to collect.

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ES-2.7 Summarize the life cycles of stars.
Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/future knowledge: The life cycle of stars is new material for this course.

It is essential for students to know that the life cycle of a star depends on its mass.

Birth of a Star

- All stars begin their lives as parts of nebulas.
- A protostar is the earliest stage of a star's life.
- A star is born when the contracting gas and dust become so hot that nuclear fusion starts.

Life of a Star

Main-Sequence stars

- The second and longest stage in a main-sequence star's life cycle takes place while the star has an ample supply of hydrogen to fuse into helium;
- When the hydrogen has fused into helium, the core of the star contracts and the outer shell expands greatly; it has become a giant star.

Massive stars

- Have many shells fusing different elements; as more shells are formed, the star expands to a larger size and becomes a supergiant star;
- The star is very luminous and uses up it fuel quickly;

Death of a Star

- When a star runs out of fuel, its core no longer releases energy, it becomes a white dwarf, a neutron star, or a black hole;
- Giants that have had their outer parts drift out into space, leave behind the blue-white hot core – a white dwarf;
- A dying supergiant star can suddenly explode; the explosion is called a supernova; material that is left behind forms a neutron star.
- The remains of the most massive stars collapse into black holes; not even light can escape from a black hole.

It is not essential for students to know the internal dynamics of what goes on within the star at the various stages of life. Temperature data and life cycle time should be relative terms.
Time permitting, some basic study of constellation may spark student's interest, but it is not essential.

Assessment Guidelines:
The objective of this indicator is to *summarize* the life cycle of stars; therefore, the primary focus of assessment should be to generalize major points about the birth, life and death of stars.
In addition to *summarize* appropriate assessments may require students to:

- *interpret* diagrams that show varying aspects of a star's life cycle;
- *compare* the life cycles of stars of different mass; or
- *recall* the possibilities that could occur at the death of a star.

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ES-2.8 Explain how gravity and motion affect the formation and shapes of galaxies (including the Milky Way).
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/future knowledge: Galaxies and their shapes were introduced in 8th grade (3-3.8). In this course understanding of the factors that influence the formation and the shapes of those galaxies are developed.

It is essential for students to know that the major components of the universe are galaxies consisting of groups of stars bound together by gravitational attraction. Galaxy formation theory is just beginning to be developed. The present view of galaxy formation holds that large systems were build up from smaller ones through collisions and mergers. Galaxies are classified by shape into three main types – spiral (normal and barred), elliptical, and irregular.

Spiral Galaxies*:*
- Contain a flattened galactic disk in which the spiral arms are found, a central galactic bulge, and a halo of faint, old stars.
- The galaxy contains both young and old stars along with gas and dust that continue formation of new stars.
- The Milky Way galaxy that contains our solar system is a spiral galaxy; it looks milky or hazy because the stars are to close together for human eyes to see them individually.
- The gas and stars in the disk move in circular orbits around the galactic center.

Elliptical Galaxies*:*
- Have no galactic disk; stars are distributed throughout the nearly spherical to very flattened shape.
- There are no obvious structures other than a dense central nucleus/
- The galaxy contains only old stars along with little or no gas and dust for new star formation.
- The stars in the galaxy move in random orbits.

Irregular Galaxies*:*
- Have no obvious structure; some have an explosive appearance.
- The galaxy contains both young and old stars with ongoing star formation.
- The gas and stars in the disk move in very irregular orbits.

It is not essential for students to know the names of specific galaxies other than the Milky Way or the further classifications within the main three. Distances between galaxies, galaxy clusters, or properties of galaxies are also not essential content for this indicator.

Assessment Guidelines:
The objective of this indicator is to *explain* the formation of galaxies and shapes of galaxies based on gravity and motion; therefore, the primary focus of assessment should be to develop cause and effect models of these concepts.
In addition to explain appropriate assessments may require students to:
- *illustrate* the shapes of galaxies;
- *compare* the three types of galaxies by description, star formation, and movement of galaxy gas and dust; or
- *recognize* the basic components of each type of galaxy.

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ES-2.9 Explain how technology and computer modeling have increased our understanding of the universe.
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/future knowledge: Students in 8th grade explained how telescopes, space probes, and satellites have been used to explore the solar system. Obtaining information beyond the solar system out into the stars and galaxies is new material for this course.

It is essential for students to know that with the development of increasingly more sensitive and sophisticated instruments, scientists are able to collect information farther and farther into the universe. Along with telescopes, devices that now collect millions of pixels of light can store the data on a disk or tape for image processing. A wide variety of non-optical telescopes and space-based observatories allow astronomers to probe regions of space that give off little or no visible light and to study many objects that emit little or no optical radiation at all. Upon gathering this information, computer programs can enhance the information to create images that help to unlock some of the mysteries hidden in the universe.

Assessment Guidelines:
The objective of this indicator is to *explain* how technology and computer modeling help to increase understanding of the universe; therefore, the primary focus of assessment should be to construct cause and effect models that show how this technology is helping in the study of the universe within and outside of our solar system.
In addition to *explain* appropriate assessments may require students to:
- *identify* types of technology that have been developed; or
- *infer* how our perceptions of the universe have changed due to this technology.